

LRO and the Planetary Data System (PDS)

Dan Scholes

Applications Programmer

NASA's Planetary Data Systems' Geosciences Node

Washington University in St. Louis

scholes@wustl.edu

3/15

What is the Planetary Data System?

- ❑ The Planetary Data System (PDS) is a NASA organization that archives science data from NASA's planetary missions.
- ❑ PDS responsibilities are:
 - To help NASA missions and other data providers to organize and document their digital planetary data,
 - To collect complete, well-documented planetary data into archives that are peer-reviewed,
 - To make the planetary data available and useful to the science community,
 - To ensure the long-term preservation and usability of the data.

PDS Nodes





- PDS is a distributed system of discipline nodes
 - The Geosciences Node is one of the nine Discipline and Support Nodes of the PDS.
- Additional Data Nodes support specific data sets
Examples:
 - LOLA Data Node
 - LROC Data Node






















PDS Data Archives

- ❑ A data set is a collection of similar data products with supporting information.
 - For example, data from one instrument with the same level of processing
- ❑ Each data set contains at least one archive volume
 - Archive volumes may be based on PDS data set release number, mission phase, time ranges, etc.

Volumes by PDS Release Number










PDS LROC Data Sets

Name	Last modified	Size	Description
 Parent Directory		-	
 LRO-L-LROC-2-EDR-V1.0/	15-Mar-2010 01:19	-	
 LRO-L-LROC-3-CDR-V1.0/	15-Mar-2010 16:50	-	
 LRO-L-LROC-5-RDR-V1.0/	11-Mar-2011 06:40	-	

Name	Last modified	Size	Description
 Parent Directory		-	
 LROLRC_0001/	07-Mar-2014 16:40	-	
 LROLRC_0002/	20-Nov-2013 11:39	-	
 LROLRC_0003/	20-Nov-2013 11:39	-	
 LROLRC_0004/	20-Nov-2013 11:39	-	
 LROLRC_0005/	20-Nov-2013 11:39	-	
 LROLRC_0006/	18-Dec-2013 15:22	-	
 LROLRC_0007/	18-Dec-2013 15:30	-	
 LROLRC_0008/	18-Dec-2013 15:30	-	
 LROLRC_0009/	18-Dec-2013 15:30	-	
 LROLRC_0010/	18-Dec-2013 15:31	-	
 LROLRC_0011/	18-Dec-2013 15:31	-	
 LROLRC_0012/	14-Dec-2014 10:25	-	
 LROLRC_0013/	14-Dec-2014 10:25	-	
 LROLRC_0014/	14-Dec-2014 10:25	-	
 LROLRC_0015/	14-Dec-2014 10:26	-	
 LROLRC_0016/	14-Dec-2014 10:26	-	
 LROLRC_0017/	14-Dec-2014 10:26	-	
 LROLRC_0018/	14-Dec-2014 10:26	-	
 LROLRC_0019/	14-Dec-2014 10:26	-	
 LROLRC_0020/	15-Dec-2014 19:49	-	

Archive volumes

- ❑ Archive volumes contain both scientific data and supporting documentation necessary to understand the data
 - Science objectives
 - Instrument configuration and calibration
 - Data acquisition, processing, and format

<u>Name</u>	<u>Last modified</u>	<u>Size</u>	<u>Description</u>
 Parent Directory		-	
 AAREADME.TXT	13-Nov-2013 15:25	4.6K	
 CATALOG/	13-Nov-2013 15:25	-	
 DATA/	07-Mar-2014 16:25	-	
 DOCUMENT/	11-Mar-2014 15:25	-	
 ERRATA.TXT	07-Mar-2014 16:40	48K	
 EXTRAS/	15-Nov-2013 12:35	-	
 INDEX/	07-Mar-2014 16:35	-	
 VOLDESC.CAT	13-Nov-2013 15:25	2.0K	

Archive Volume Directory

PDS Labels

- ❑ Each PDS data product has an associated PDS label.
- ❑ PDS labels contain metadata needed to understand and use data products.
- ❑ Labels are ASCII text in the form of keyword=value lines.
- ❑ PDS uses a data dictionary to provide standards for use of keywords and their values.

PDS Label Example

```
PDS_VERSION_ID      = "PDS3"
RECORD_TYPE         = FIXED_LENGTH
RECORD_BYTES        = 44
FILE_RECORDS        = 2556

^TABLE              = "GLTM2BSH.TAB"
SPACECRAFT_NAME     = "CLEMENTINE 1"
TARGET_NAME         = "MOON"
INSTRUMENT_NAME     = "LIDAR"
DATA_SET_ID         = "CLEM1-L-LIDAR-5-TOPO-V1.0"
PRODUCT_ID          = "GLTM2B-SH"
PRODUCT_RELEASE_DATE = 1996-01-01
DESCRIPTION          = ""

OBJECT              = TABLE
  ROWS              = 2556
  COLUMNS          = 4
  ROW_BYTES         = 44
  INTERCHANGE_FORMAT = ASCII
  DESCRIPTION       = ""
```

```
OBJECT              = COLUMN
  NAME              = "COEFFICIENT DEGREE"
  DATA_TYPE        = ASCII_INTEGER
  START_BYTE        = 1
  BYTES             = 2
  FORMAT            = "I2"
  UNIT              = "N/A"
  DESCRIPTION       = "The degree index m of the C and S
                      coefficients in this record."
END_OBJECT          = COLUMN

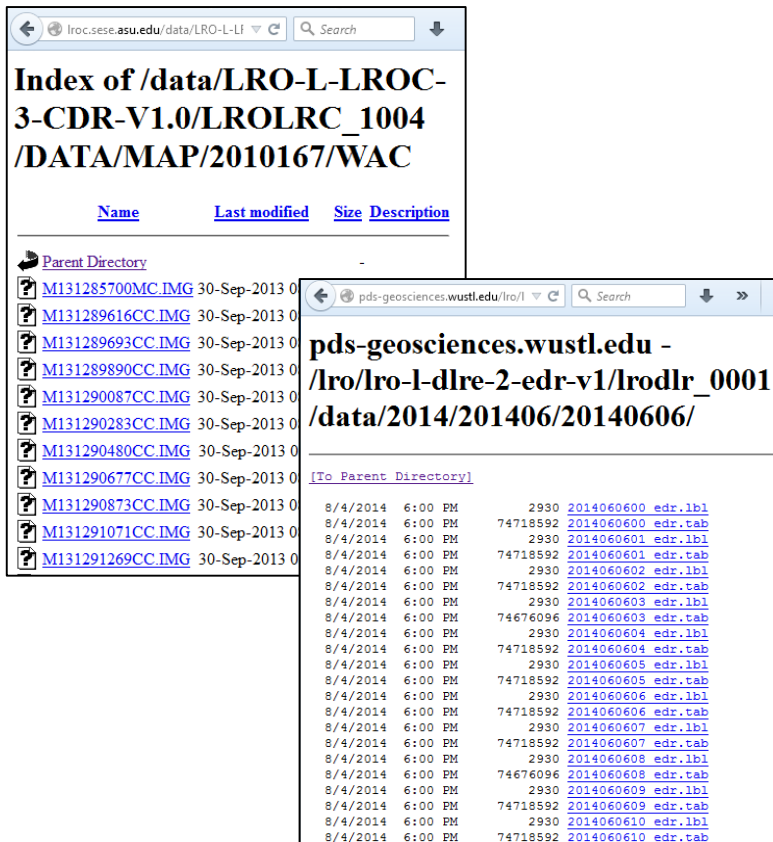
OBJECT              = COLUMN
  NAME              = "COEFFICIENT ORDER"
  DATA_TYPE        = ASCII_INTEGER
  START_BYTE        = 4
  BYTES             = 3
  FORMAT            = "I3"
  UNIT              = "N/A"
  DESCRIPTION       = "The order index n of the C and S
                      coefficients in this record."
END_OBJECT          = COLUMN
END_OBJECT          = TABLE
END
```

Locating PDS LRO Archives



- Geosciences - <http://geo.pds.nasa.gov>
 - DIVINER, LEND, Mini-RF
 - LOLA Data Node – <http://imbrium.mit.edu>
 - LOLA, Radio Science (LOLA Data Node)
- Imaging - <http://img.pds.nasa.gov>
 - LAMP
 - LROC Data Node - <http://lroc.sese.asu.edu>
- PPI - <http://ppi.pds.nasa.gov>
 - CRaTER
- NAIF - <http://naif.jpl.nasa.gov>
 - SPICE Data
- PDS - <http://pds.jpl.nasa.gov>

Direct Download of Data Set Files



The image shows two browser windows. The left window displays the 'Index of /data/LRO-L-LROC-3-CDR-V1.0/LROLRC_1004/ /DATA/MAP/2010167/WAC' with columns for Name, Last modified, Size, and Description. It lists files like M131285700MC.IMG. The right window shows a directory listing from pds-geosciences.wustl.edu for the path /lro/lro-l-dlre-2-edr-v1/lrodlr_0001/data/2014/201406/20140606/, listing files like 2014060600.edr.tbl with their sizes and timestamps.

- HTTP directory access (all nodes)
 - Manual browser downloads
 - Browser plugins
 - DownloadThemAll
 - Wget
 - Scripts and programs
- FTP directory access (Geo Node)
 - Manual browser downloads
 - FTP clients
 - Command line
 - Wget
 - Scripts

PDS Imaging Node's Planetary Image Atlas

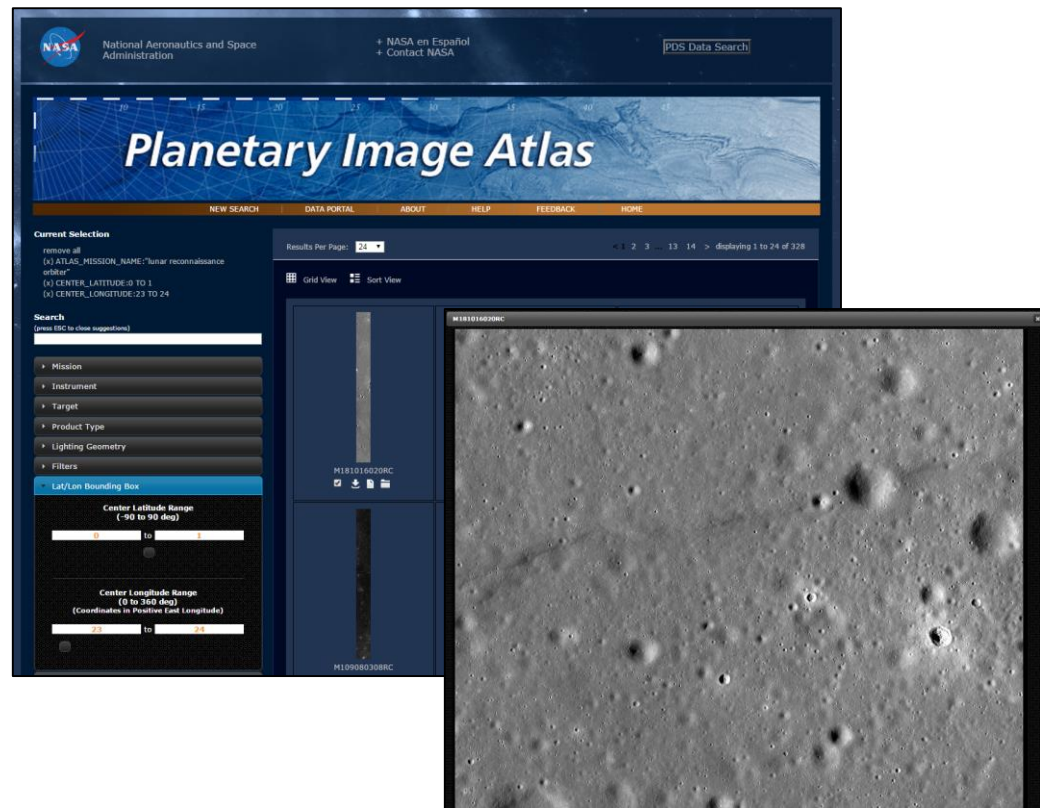
□ LRO Support

- LAMP
- LROC

□ Provides

- Search
- Browse
- Download

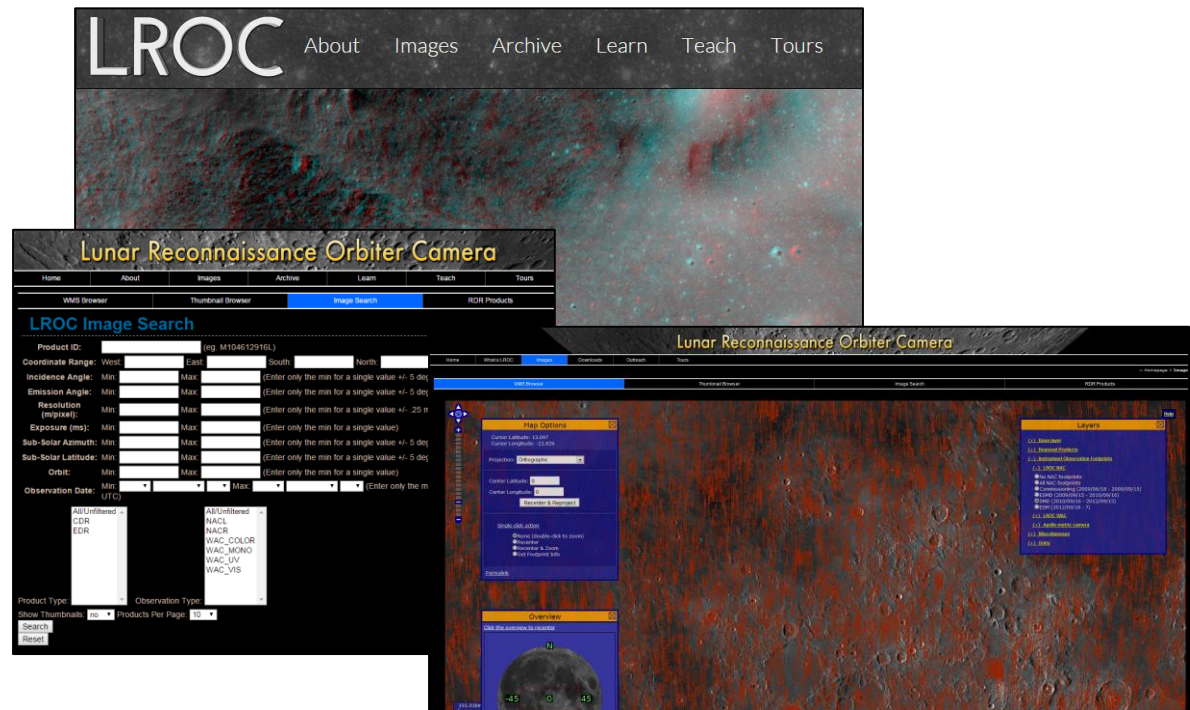
<http://img.pds.nasa.gov/search>



LROC PDS Data Node

□ LROC Specific <http://lroc.sese.asu.edu>

- Provides
- Search
 - Map
 - Browse
 - Download



PDS Geosciences Node's Orbital Data Explorer (ODE)

□ LRO Support

- DIVINER
- LAMP
- LEND
- LOLA
- LROC
- Mini-RF

□ Provides

- Search
- Map
- Browse
- Download

<http://ode.rsl.wustl.edu/moon>

The screenshot displays the Lunar Orbital Data Explorer (ODE) web application. The interface is divided into several sections:

- Header:** Includes the title "Lunar Orbital Data Explorer" and the affiliation "PDS Geosciences Node, Washington University in St. Louis". Navigation links for Home, Data Product Search, Tools, Data Set Browser, Download, and Help & Resources are provided.
- DATA PRODUCT SEARCH:** A section explaining that planetary science data is organized by data products and data sets, and that a data set is a collection of related data products.
- STEP 1. SELECT DATA SETS TO SEARCH (A SELECTION IS REQUIRED):** A section with a "Select One or More Desired Data Sets" button and a "(Show Options - 1 Parameter)" link.
- STEP 2. SET ADDITIONAL FILTERING PARAMETERS (OPTIONAL):** A section with three filtering options: "Select a Product ID or filter by a partial Product ID", "Find by Product Center Latitude / Longitude", and "Filter by Time Range". Each option has a "(Show Options - 0 Parameters)" link.
- STEP 3. PREVIEW SEARCH RESULTS SUMMARY:** A section with a "Preview Search Results Summary" button.
- STEP 4. SUBMIT QUERY:** A section with "View Results in Table" and "View Results in Map" buttons, and a checkbox for "Display Product Thumbnails on search results".
- Search Results:** A table listing search results with columns for Product ID, Instrument, and Date. The table shows a list of products from the LRO LROC CDR instrument, dated 2009-06-30.
- Map Display Controls:** A section with buttons for "Select Layers", "Set Filters (Optional)", and "View Selection Results". It also includes a "Map Display Controls" section with buttons for "Zoom In", "Zoom Out", "Full Extent", "Prev Extent", "Next Extent", and "Pan".
- SELECTION RESULTS SUMMARY:** A section showing the search results summary, including "Product Type", "Search Results Count", and "Total Products Found".
- SELECTION RESULTS LIST:** A section showing the list of selected products, including "Products Found: 32" and "Display Product Thumbnails".
- Map:** A map showing the lunar surface with a red box indicating the selected area.
- Product Details:** A section showing details for a selected product, including "Product ID", "Instrument", "Product ID", and "Date". It also includes a "Browse Image" button and a "Download Image" button.

Lunar Orbital Data Explorer (ODE)

- Allows users to:
 - search across missions and instruments
 - search across PDS nodes
- Supports additional PDS-Compliant lunar archives from:
 - Clementine
 - GRAIL
 - ISRO Chandrayaan-1
 - Forerunner (Mini-RF), Moon Mineralogy Mapper (M³)
 - Lunar Orbiter
 - Lunar Prospector

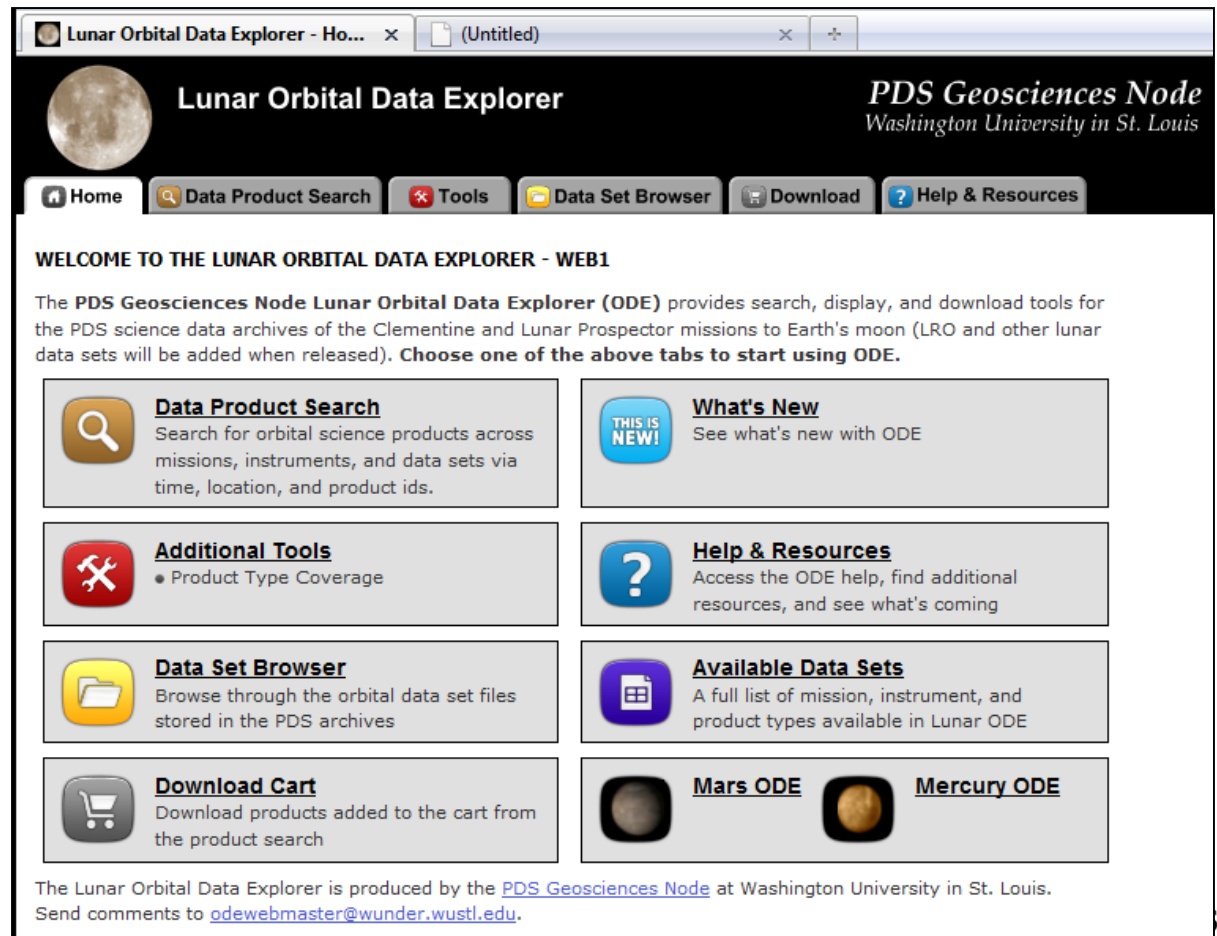
ODE Highlights

- ❑ Form and map product searches
 - Mission / Instrument / Product Type
 - Location, Time, and Observation Angle
 - Exact or partial Product ID searches
- ❑ Product detail pages
 - Product meta data
 - Browse images
 - Product and associated files
 - Related products
 - Map context
 - Links to product-specific web interfaces (LROC Data Node)
 - Data set information
- ❑ Direct file downloads and cart system
 - Cart includes “on-the-fly mini-archive” option

Example:

Find DIVINER Products in ODE

Open ODE Moon: <http://ode.rsl.wustl.edu/moon>












The screenshot shows the Lunar Orbital Data Explorer (ODE) web application. The browser window has two tabs: "Lunar Orbital Data Explorer - Ho..." and "(Untitled)". The page header features a moon image, the title "Lunar Orbital Data Explorer", and the affiliation "PDS Geosciences Node Washington University in St. Louis". A navigation bar contains links: Home, Data Product Search, Tools, Data Set Browser, Download, and Help & Resources. The main content area is titled "WELCOME TO THE LUNAR ORBITAL DATA EXPLORER - WEB1" and provides a brief description of the application. Below this, there are eight interactive boxes arranged in a grid. The first four boxes are: "Data Product Search" (with a magnifying glass icon), "What's New" (with a "THIS IS NEW!" icon), "Additional Tools" (with a wrench icon), and "Help & Resources" (with a question mark icon). The next two boxes are: "Data Set Browser" (with a folder icon) and "Available Data Sets" (with a document icon). The final two boxes are: "Download Cart" (with a shopping cart icon) and a section for "Mars ODE" and "Mercury ODE" (each with a planet icon). At the bottom, a footer states that the application is produced by the PDS Geosciences Node at Washington University in St. Louis and provides an email address for comments.

Lunar Orbital Data Explorer
PDS Geosciences Node
Washington University in St. Louis

Home Data Product Search Tools Data Set Browser Download Help & Resources

WELCOME TO THE LUNAR ORBITAL DATA EXPLORER - WEB1

The PDS Geosciences Node Lunar Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the Clementine and Lunar Prospector missions to Earth's moon (LRO and other lunar data sets will be added when released). **Choose one of the above tabs to start using ODE.**

 Data Product Search Search for orbital science products across missions, instruments, and data sets via time, location, and product ids.	 What's New See what's new with ODE
 Additional Tools • Product Type Coverage	 Help & Resources Access the ODE help, find additional resources, and see what's coming
 Data Set Browser Browse through the orbital data set files stored in the PDS archives	 Available Data Sets A full list of mission, instrument, and product types available in Lunar ODE
 Download Cart Download products added to the cart from the product search	 Mars ODE  Mercury ODE

The Lunar Orbital Data Explorer is produced by the [PDS Geosciences Node](#) at Washington University in St. Louis. Send comments to odewebmaster@wunder.wustl.edu.

Find DIVINER in ODE - Search

1) Select Data Product Search Tab

2) Open the Select One or More Desired Data Sets

Lunar Orbital Data Explorer

PDS Geosciences Node
Washington University in St. Louis

Home Data Product Search Tools Data Set Browser Download Help & Resources

DATA PRODUCT SEARCH [Reset Form](#)

Planetary science data stored in PDS is organized by [data products](#) and [data sets](#). A data set is a collection of related data products, usually products acquired by a particular instrument and processed in a certain way. The data set also includes all documentation and supporting materials needed to understand and use the data products. A data product is a set of measurements resulting from a science observation, usually products acquired by a particular instrument and processed in a certain way.

STEP 1. SELECT DATA SETS TO SEARCH (A SELECTION IS REQUIRED)

☒ Select One or More Desired Data Sets (Show Options - 1 Parameter Set)

STEP 2. SET ADDITIONAL FILTERING PARAMETERS (OPTIONAL)

☒ Select a Product ID or filter by a partial Product ID (Show Options - 0 Parameters Set)

☒ Find by Product Center Latitude / Longitude (Show Options - 0 Parameters Set)

☒ Filter by Time Range (Show Options - 2 Parameters Set)

STEP 3. PREVIEW SEARCH RESULTS SUMMARY (OPTIONAL)

[Preview Search Results Summary](#)

STEP 4. SUBMIT QUERY

[View Results in Table](#) [View Results on Map](#)

☒ Display Product Thumbnails on search results page

Find DIVINER in ODE - Search

Lunar Orbital Data Explorer

PDS Geosciences Node
Washington University in St. Louis

Home Data Product Search Map Search Tools Data Set Browser Download Help

DATA PRODUCT SEARCH [Reset Form](#)

Planetary science data stored in PDS is organized by [data products](#) and [data sets](#). A data set is a collection of related data products, usually products acquired by a particular instrument and processed in a certain way. The data set also includes all documentation and supporting materials needed to understand and use the data products. A data product is a set of measurements resulting from a science observation, usually products acquired by a particular instrument and processed in a certain way.

STEP 1. SELECT DATA SETS TO SEARCH (A SELECTION IS REQUIRED)

Select One or More Desired Data Sets (Released PDS Archives) (Hide Options - 1 Parameter Set)

- Map location data is available for these products.
- Observation time data is available for these products.
- This data set is currently being processed in ODE. [Click for more detail](#)

Lunar Reconnaissance Orbiter

DLRE - DIVINER Lunar Radiometer Experiment

- ☐ RDR - Reduced Data Rec. (See Tools: DIVINER RDR Query Tool)
- ☐ GDR_L2 - Gridded Data Record Level 2
- ☒ GDR_L3 - Gridded Data Record Level 3
- ☐ PRP - Gridded Data Record Polar Resource Products

Other Product Types

- Select:
 - GDR_L3

•EDRs are available under here

Find DIVINER in ODE - Search

OPTIONALLY:

1) Filter by:

- Product Id,
- Location,
and/or
- Time Range

2) Click “Preview Search Result Summary”

FINALLY:

3) Select
“View Results in Table”

☐ RDR - Neutron Counting Rate Reduced Data Record [Data Set Description](#)

RSS - Radio Science Subsystem

☐ GRAV - Gravity [Data Set Description](#)

☐ LOSAPDR - Line of Sight Acceleration Profile Data Record [Data Set Description](#)

Lunar Orbiter

24INCH_FLC - 24 Inch Focal Length Camera

☐ CDR - Calibrated Data Record [Data Set Description](#)

80MM_FLC - 80mm Focal Length Camera

☐ CDR - Calibrated Data Record [Data Set Description](#)

STEP 2. SET ADDITIONAL FILTERING PARAMETERS (OPTIONAL)

☒ Select a Product ID or filter by a partial Product ID (Hide Options - 1 Parameter Set)

Each PDS data product has a unique [product id](#). Individual data products can be found with an exact match or multiple products can be found using the the wild card parameter. New users [click here](#) for further details.

Product ID: use wildcard * after or before a partial Product ID

☒ Find by Product Location (Show Options - 0 Parameters Set)

☒ Filter by Time Range (Show Options - 0 Parameters Set)

STEP 3. PREVIEW SEARCH RESULTS SUMMARY (OPTIONAL)

[Preview Search Results Summary](#)

Product Type	Search Results Count
LRO DLRE GDR_L3	184
Total Products Found	184

STEP 4. SUBMIT QUERY

☒ View Results in Table ☐ Select Results on Map Display


☒ Display Product Thumbnails on search results page

Search Results & Product Details Page

Product Details

Features:

- Review browse, metadata, and label
- Review data set documentation including SISs
- Download individual files
- Add product to download cart



Lunar Orbital Data Explorer

PDS Geosciences Node

Washington University in St. Louis

[Home](#) [Data Product Search](#) [Map Search](#) [Tools](#) [Data Set Browser](#) [Download](#) [Help & Resources](#)

SEARCH RESULTS

[Output Results](#) [View on Map](#) [Back To Search](#)

Products Found: 1,360

☒ Display Product Thumbnails

Update Cart

<< 5 6 7 8 9 10 11 12 13 14

Instrument	Type	Product ID	Obs Time	
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110817N_240_IMG.IMG	2011-08-31T00:00:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110817N_240_JP2.JP2	2011-08-31T00:00:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110830D_240_IMG.IMG	2011-09-13T14:00:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110830D_240_JP2.JP2	2011-09-13T14:00:00.000	<input checked="" type="checkbox"/> In Cart
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110913N_240_IMG.IMG	2011-09-27T07:00:00.000	<input checked="" type="checkbox"/> In Cart
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110913N_240_JP2.JP2	2011-09-27T07:00:00.000	<input checked="" type="checkbox"/> In Cart
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110927D_240_IMG.IMG	2011-10-10T21:00:00.000	<input checked="" type="checkbox"/> In Cart
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20110927D_240_JP2.JP2	2011-10-10T21:00:00.000	<input checked="" type="checkbox"/> In Cart
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111010N_240_IMG.IMG	2011-10-24T13:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111010N_240_JP2.JP2	2011-10-24T13:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111024D_240_IMG.IMG	2011-11-07T03:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111024D_240_JP2.JP2	2011-11-07T03:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111107N_240_IMG.IMG	2011-11-20T20:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111107N_240_JP2.JP2	2011-11-20T20:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111120D_240_IMG.IMG	2011-12-04T13:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111120D_240_JP2.JP2	2011-12-04T13:30:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111204N_240_IMG.IMG	2011-12-13T12:00:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111204N_240_JP2.JP2	2011-12-13T12:00:00.000	<input type="checkbox"/>
LRO DLRE	GDR_L3	DGDR_TBOL_AVG_POLS_20111218D_240_IMG.IMG	2011-12-25T02:30:00.000	<input type="checkbox"/>

DGDR_TBOL_AVG_POLS_20110830D_240_JP2.JP2

Product Description: " Each sample represents the B ([more...](#))
[More About this Product Type \(help page\)](#)
[PDS Volume](#) [AAREADME.TXT](#) [ERRATA.TXT](#) [Catalog Files](#) [Document Files](#)
[Data Product Software Interface Specification \(PDF\)](#)
[Archive Software Interface Specification Document \(PDF\)](#)
[PDS Source Location](#)

[Browse](#) [Meta Data](#) [Label](#) [Related Products](#) [Map Context](#)

Browse Image - the image below is not the actual data product



South Pole

0° 180°

0 50 100 150 200 250 300 350 400 K

TBOL_AVG_POLN

[Add Product to Cart](#) [Remove Product from Cart](#) [Cart & Download Help](#)

PDS Product Files

Derived Files

Product Files & Labels	KB
dgdr_tbol_avg_pols_20110830d_240_ip2.jp2	15,524
Product Data File	
dgdr_tbol_avg_pols_20110830d_240_ip2.lbl	4
Product Label File	

ODE – Map Search

Zoom/Pan Map

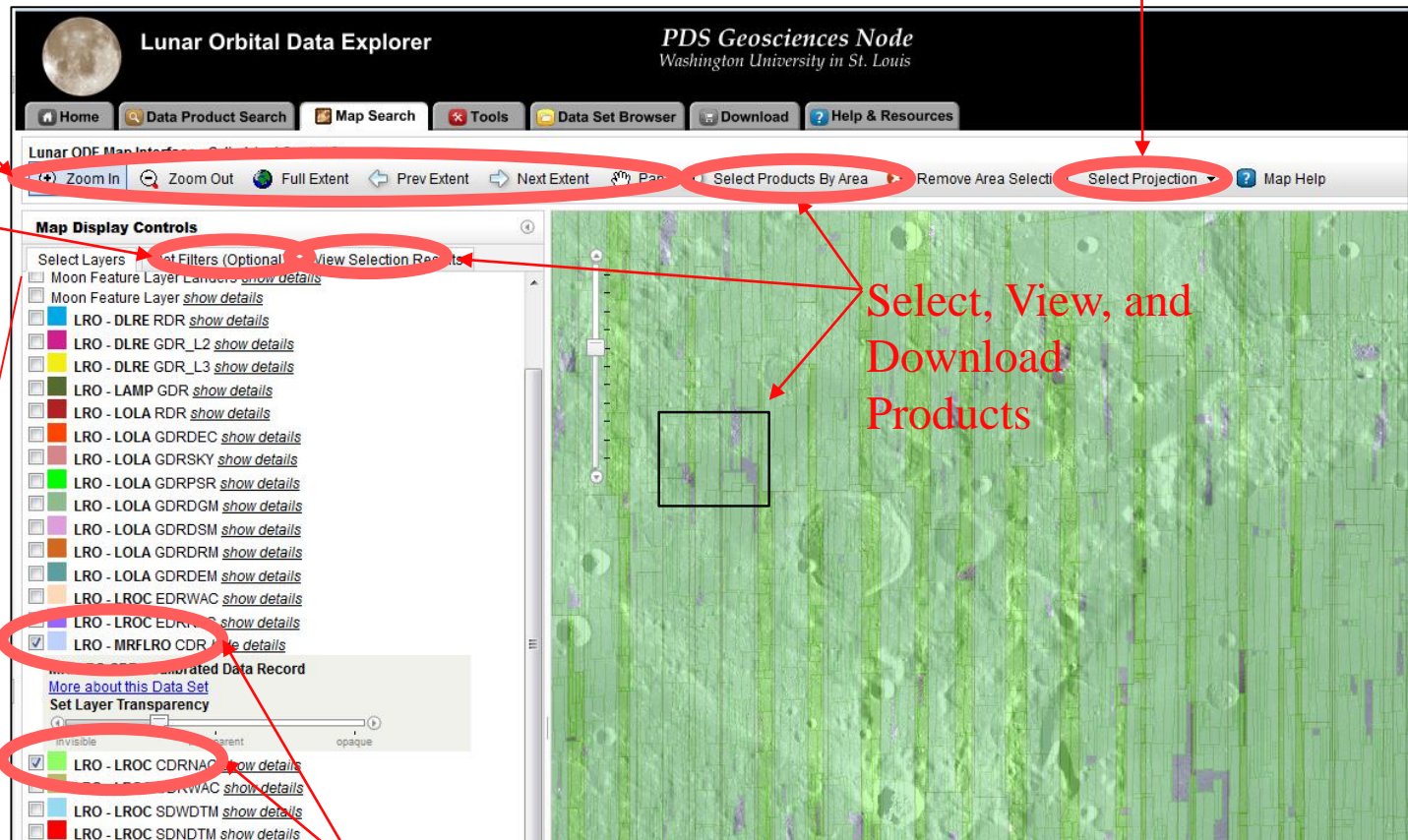
Filter Products by

- Time
- Product Id
- Location

Control Map Layers

- Transparency
- Layer Order
- Footprint Layers
- Basemap Layers

Select Projection



Select one or more product type footprint layers

Additional ODE LRO Tools

<http://ode.rsl.wustl.edu/moon/indextools.aspx>

- LOLA RDR Query Tool
 - Database of all RDR records
 - ~6.5B individual points
 - Query by feature, location, orbit, time, product id, altitude range, and channels
- DIVINER RDR Query Tool
 - Database of all RDR records
 - ~223B individual points
 - Query by feature, location, orbit, time, product id, channel, detector, emission angle, solar incidence angle, solar azimuth angle, local time of day, and quality flags

Questions?

- Visit us at the PDS Geosciences Booth
 - Get detailed answers
 - Walk through your usage scenario
 - Share your feedback
- Contacts:
 - Dan Scholes
 - scholes@wustl.edu